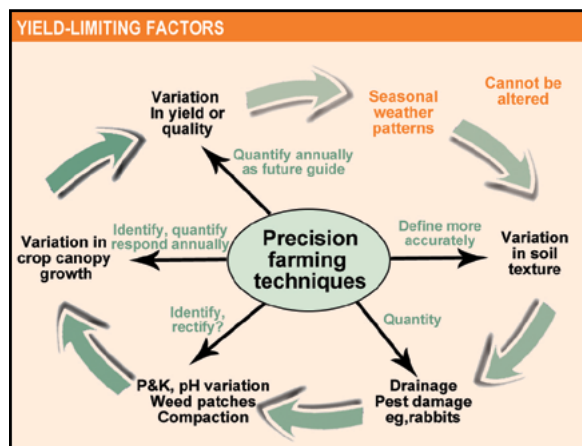


## Chapter 14: Precision Wheat Management



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Three chapters in this publication discuss precision wheat management (Chapters 14, 15, and 16). Many people perceive precision agriculture as solely grid soil sampling and applying variable rate fertilizer applications. While these are two techniques used by producers, precision farming is a way of thinking rather than the adoption of new technologies. Precision farming uses local information to improve management (Fig. 14.1). Treatments can be applied using variable or non-variable rate equipment. The objectives of this chapter are to provide an overview and to discuss guidelines for integrating precision farming into your operation.



**Figure 14.1. Reducing yield limiting factors with precision farming.**

(Source: <http://www.fwi.co.uk/Articles/23/08/2010/115957/Precision-farming-2-Crop-agronomy.htm>)

## Precision farming overview

Agriculture is being changed by improved low-cost informational technologies, molecular biology, and field equipment that provide the opportunity for implementing site-specific management. Through precision farming, all three technologies can be packaged and delivered to producers. Who would have thought 50 years ago that:

- A significant percentage of tractors, traversing our vast fields, would be traveling under the control of autosteer systems rather than driven by farmer-operators?
- A family operation could effectively farm 4000 acres?
- Our major defensive mechanisms in our battles with pests would come in our seed bags?
- Satellites would provide information needed to improve our management systems?

We are entering a new era in production agriculture, an era dominated by site-specific spatial management of farming inputs. This is an era where the agricultural foundations have undergone revolutionary changes. For centuries, agronomy was dominated by the biological sciences and the ability to work hard. Now we are witnessing an era where creativity and mathematics are becoming of equal importance. In precision agriculture, many of the current recommendation guidelines are being evaluated. Many of the concepts behind precision farming have been integrated into a number of books, such as:

*Site Specific Management Guidelines*

<http://ppi-store.stores.yahoo.net/sitmanguid.html>

*GIS Applications in Agriculture, 2007*

<http://www.crcpress.com/product/isbn/0849375266>

*Mathematics and Calculations for Agronomists and Soil Scientists*

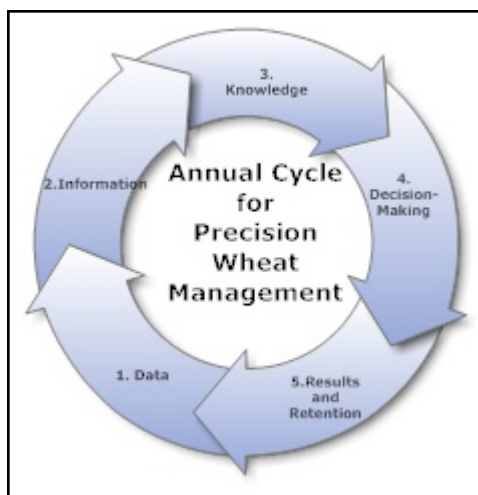
<http://ppi-store.stores.yahoo.net/maandcaforag.html>

*GIS Applications in Agriculture: Nutrient Management for Improved Energy Efficiency*

<http://www.crcpress.com/product/isbn/0849375266>

It makes intuitive sense that site-specific recommendations are a function of the yield potential, climate, and soil variability. Areas with higher yield potentials often require higher inputs, while areas with lower yield potentials require less. In South Dakota, many fields contain significant spatial variability of yield, which is most often directly related to landscape position. Across these landscapes, water and salts are often the major factors that control yield.

In a given year, yields in the summit/shoulder areas are reduced by too little water, while yields in footslope/toeslope areas are reduced by too much water. In many fields, the availability of nutrients or occurrence of pests may further reduce these yields. To maximize yields and improve the efficient use of resources, inputs must be matched to the conditions existing at each landscape location. Precision farming provides the capability to convert locally derived information into improved decisions (Fig 14.2).



**Figure 14.2. Idealized annual process/cycle applied to precision wheat management.** (Source: Kevin Dalsted, SDSU)

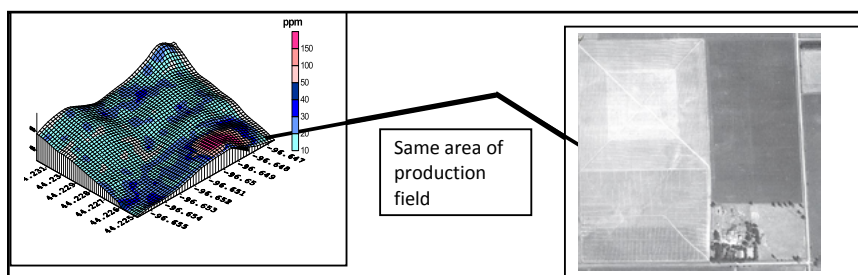
### Integrating precision farming into your operation

All producers struggle to translate data into timely and informed decisions. The idealized management cycle is portrayed in Figure 14.2. Using soil fertility as the example, in Step 1 data (e.g., soil samples and associated lab data) is collected. Step 2 is deriving information from the lab data, such as comparing soil test values with fertilizer recommendations. Step 3 draws on the producers' knowledge (experience) to consider how and where to apply the fertilization by type, distribution and timing. Step 4 covers the final management decision(s) in a given year by translating the knowledge into the ground operations. Step 5 is the post-harvest evaluation when effectiveness of the practices is evaluated. What happened in a given year(s) can be used to tweak the first 4 steps, depending upon the situation (real and anticipated).

Making the best decision in a timely manner, given the circumstances of a particular year, is the key to profitability and sustainability. The application of precision agriculture to wheat management can aid in making these decisions. Many factors are beyond the control of the producer, such as weather, pests, crop prices, etc., but precision farming can aid in helping manage those factors that are within the control of the producer.

### Precision farming guideline highlights

1. When using composite soil sampling, it is highly recommended to not include areas where old homesteads were located. Including these areas will reduce fertilizer recommendations, resulting in yield losses.



**Figure 14.3. The impact of prior management on current soil test values.** This homestead was removed from the landscape in the 1950s. The grid soil sampling was conducted in 1995. (Clay et al. 2006)

- Yield monitor data can be used to partition fields into different categories. Two common categories are high yield – high stability and low yield – high stability. Software programs are available at South Dakota State University and The Upper Midwest Aerospace Consortium (UMAC)(Chapter 16).
- Crop management zones can be developed on the basis of soils, yield monitor data, computer classification based on elevation or electrical conductivity, and/or crop spectral reflectance (Chapter 15). USDA soils data is readily accessible in a digital format (Chapter 18). Yield monitor and remote sensing data can be used to partition fields into zones (Fig. 14.4). Examples and case studies for determining zones are available in:

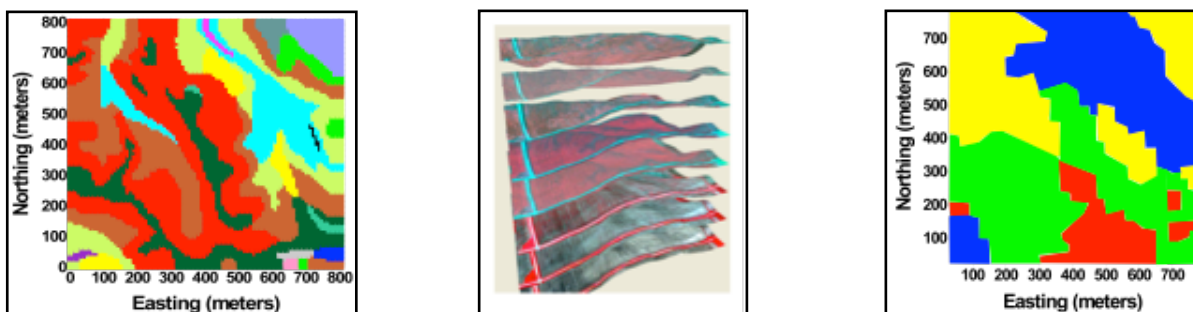
*GIS Applications in Agriculture*

<http://www.crcpress.com/product/isbn/0849375266>

*GIS Applications in Agriculture: Nutrient Management for Improved Energy Efficiency*

<http://www.crcpress.com/product/isbn/0849375266>

- On-farm testing is a means of assessing current practices. In this approach, the experiments should be conducted over multiple years and replications should be included. Information about on-farm research is provided in Chapters 32 and 33. Questions about on-farm studies should be directed to Gregg Carlson ([gregg.carlson@sdstate.edu](mailto:gregg.carlson@sdstate.edu)).



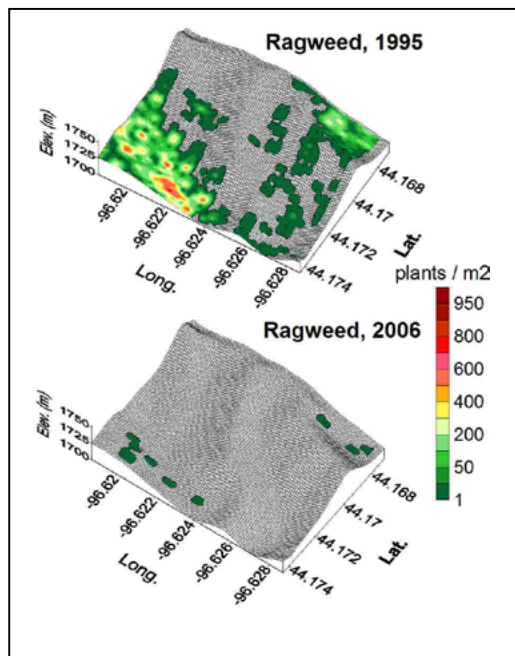
**Figure 14.4.** Several different approaches can be used to define management. (Modified by Clay et al.)

- Profitability and nutrient removal maps can be developed. Nutrient removal rates for wheat are shown in Table 14.1. More information can be found in Chapter 12. Yield variations can result in differential removal rates. For example, areas of fields with yields of 60 and 40 bu/acre will remove 36 and 24 lbs  $P_2O_5$ /acre, respectively. If P was uniformly applied, then differential removal can result in relatively low concentrations in the high yielding area (Fig. 14.3). Nutrient removal maps can be developed with nutrient removal data below.

**Table 14.1.** Nutrient removal rates for wheat.

Type	Unit	Nutrient								
		N	$P_2O_5$	$K_2O$	B	Ca	Cu	Fe	S	Zn
Wheat Grain	Lbs/bushels	100	60	34	0.1	3.3	0.083	0.75	10	35
Wheat Straw	Lbs/ton	14	3.3	24	--	--	--	--	2.8	--

- Fertilizer and pest management programs can be assessed by comparing maps or information from different years. Grid sampling for pests can be used to document pest management effectiveness (Fig. 14.5).



**Figure 14.5. Common ragweed (*Ambrosia artemisiifolia*) estimated densities in 65 ha field pre- (1995) and post (2006)-adoption of Roundup Ready® corn and soybean. Weeds were counted at 2500 grid points in the eastern South Dakota field in the spring just prior to post-emergence weed control application. Conservation tillage was used in the field. (Modified from Chang et al. 2003)**

### Precision farming tools

To implement adaptive management techniques, locally-based experiments must be conducted. Details about the design and analysis of these experiments are provided in Chapters 32 and 33. Yield monitors, scouting, remote sensing, and on-farm research are techniques to collect this data/information.

Data can be collected from these experiments using many different approaches.

Remote sensing data can be obtained from the South Dakota View <http://www.sdstate.edu/abe/sdview/index.cfm> or Upper Midwest Aerospace Consortium <http://dngp.umac.org/newdngp372/index.php>

The Upper Midwest Aerospace Consortium has written a program Digital Northern Great Plains that can be used to develop management zones. <http://dngp.umac.org/newdngp372/index.php>

A step-by-step guide for using this program is available in Clay and Shanahan (2011). [http://www.crcpress.com/product/isbn/9781420092707;jsessionid=OkXJUfa2dnldIJp2H5EsiQ\\*\\*](http://www.crcpress.com/product/isbn/9781420092707;jsessionid=OkXJUfa2dnldIJp2H5EsiQ**)

Soils information can be obtained from the USDA-NRCS soils database. See Chapter 18. <http://soils.usda.gov/survey/geography/ssurgo/>

Multiple years of yield monitor data/information can be used to identify management zones and assess the effectiveness of various treatments. Step-by-step protocols for deriving knowledge from soil information/data and field scouting are available in the GIS Applications in Agronomy book series. <http://www.crcpress.com/product/isbn/0849375266>

One of the most widely used approaches for collecting on-site data/information is to measure the apparent electrical conductivity (ECa). Systems for measuring ECa are manufactured and marketed by Veris Technologies (Salina, Kansas) <http://www.veristech.com/products/soilec.aspx> and Geonomics Limited (Mississauga, Ontario).

Data from these systems can be linked with latitude and longitude information collected with differentially corrected global positioning systems (DGPS) so as to develop elevation contour maps. These systems are used to:

- Identify management zones.
- Identify yield-limiting factors.
- Conduct a rapid identification of farm field variability.
- Provide guidance for soil sampling.
- Provide information about soil discontinuities.

### **Global positioning and geographic information systems**

Many current precision farming applications rely on differentially corrected global positioning systems (DGPS). With DGPS the latitude and longitude values at specific points are identified. DGPS, or similar systems, is used by self-guided tractors (Autosteer), parallel swathing, and grid soil sampling.

Another important precision agriculture component is geographic information systems (GIS). GIS allow the user to display a variety of digital maps and their associated attributes. The Web Soil Survey web site is a great example of a data source that shows the potential of GIS applications (Chapter 18). Furthermore, using GIS functions can bring together various levels of data, such as potential yields by soil map units compared to the actual yield map coupled with an annual rainfall distribution map. Comparing multiple years of field data can also be informative.

From a user's perspective, one way of looking at GIS is to consider the "staying power" of the digital maps and its associated data attributes. For example, a digital topographic map with its elevation information can be thought to be relatively stable (earthquakes, mudslides and human activities, notwithstanding); depth to aquifer, vegetation climate zone, and soil survey maps are a few other examples.

Intermediate "stability" might be illustrated by annual cropping land cover maps, periodic census counts (human or wildlife), and annual fertilizer usage. Short-term examples could include daily relative humidity numbers, rain accumulations, wind speed, etc. The reason for discussing these three levels is to illustrate the need to consider collection frequency. As some data expire quickly, they need to be refreshed more often than the so-called stable data. [http://www.ebookpdf.net/ebook-pdf\\_gis-applications-in-agriculture\\_1093.html](http://www.ebookpdf.net/ebook-pdf_gis-applications-in-agriculture_1093.html)

In summary, precision farming is an approach where locally derived information and knowledge is integrated into the decision process. There are many tools that can be used to help implement these decisions. Currently research is being conducted to better define and refine the site-specific management recommendations as well as develop new tools that simplify the processing of such information. As the mountain of data accumulates for producers, tools associated with precision agriculture will provide an effective means of scaling that mountain, while preserving the integrity and value of the data/information/knowledge and providing the all-important time efficiencies that are needed.



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### Acknowledgements

Support for this chapter was provided in part by South Dakota Soybean Research and Promotion Council, South Dakota Corn Utilization Council, South Dakota Wheat Commission, NASA through the Upper Midwest Aerospace Consortium and the SD Space Grant Consortium, USDA-NCSARE, the South Dakota Agricultural Experiment Station, USDA-CSREES, and SD 2010 Initiative.

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